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Selected Ant Attractive and Chemical Repellent Materials under Climatic Factors affecting the Population Fluctuations of the Common Black Little Ant, *Monomorium carbonarium* (F. Smith, 1858) (Hymenoptera: Formicidae)

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ABSTRACT

The current work is to study the effectiveness of attractive and some chemical materials under the impact of ambient physical parameters on the black little, *Monomorium carbonarium* population fluctuations. New modified pitfall and baits trap used for outdoor and indoor trials, respectively. Ten attractants (sugar, rice, peanuts, kidney beans, dry dates, ajwa, wheat, coconut, currant, and honey) and three repellent materials (Butex, chalk, and vinegar) were used. Furthermore, the greatest number of ants attracted to honey (4057 individuals) representing 19.45 %. However, the lowest numbers were for kidney beans (461 individuals) with 2.21 %. Additionally, the highest number was collected on vinegar (78 individuals), in contrast, the lowest numbers were in chalk (6 individuals). On the other hand, both maximum and minimum temperatures had a substantial positive effect on the abundance of ants on attractants at whole sites except site (E) having a significant negative effect. Furthermore, relative humidity had a significant positive effect at sites (A), (D), and (E), and a negative significant effect on other sites. It was concluded, that *M. carbonarium* may be attracted to honey and coconut. Moreover, the presence of *M. carbonarium* was inversely proportional to temperatures and directly to relative humidity to control *M. carbonarium* used chalk in our habitats. Therefore, it is recommended that studied materials should be stored in arid and closed places. Moreover, chalk as a powder can be used as a repellent material for this species.

INTRODUCTION

Ants (Hymenoptera: Formicidae) are among the most abundant groups, a very important and major component of invertebrates in terrestrial ecosystems, presenting a variety wide range of nesting sites, feeding habits, and interactions with organisms from all trophic levels said by (Kaspari, 2000). Further, ants are sensitive to changes in environmental factors concluded by (Kaspari and Majer, 2000; Andersen *et al.*, 2002; Watt *et al.*, 2002 and Brühl *et al.*, 2003).

In Egypt, the earliest inventory of ants consisted of 69 species and 20 estimated undescribed species in 24 genera, classified under 5 subfamilies. In addition, most of the

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ant diversity is found within five main subfamilies: Myrmicinae, Formicinae, Ponerinae, Dorylinae, and Pseudomyrmecinae (AntWeb, 2022).

Ant foraging ranges and behavior are affected by several factors, such as temperature, food availability, food particle size, photoperiod, circadian rhythm, and competition concluded by (Hölldobler and Wilson, 1990). Different ant species have various dietary requirements, and consequently, this must be regarded during ant bait formulation. Moreover, effective proportions of fat, protein, and carbohydrates in the bait may vary between species and with the colonies' nutritional needs reported by (Rust *et al.*, 2000). The rate of collection of the bait is also affected by the physical state of the bait, solid versus liquid, and particle size concluded by (Hooper-bui and Rust, 2000).

The little black ants, *Monomorium carbonarium* were originally described from Madeira and belong to the minimum species group and are supposed to be in their normal habitat with the Azores (Wetterer *et al.*, 2004 and Wetterer *et al.*, 2007). Outside their native ranges, they have been permanently presented to many countries. According to Ant maps, recent records are from the United States (O'Keefe *et al.*, 2000), Egypt (Mohamed *et al.*, 2001), Iraq (Abdul-Rassoul *et al.*, 2013), and France (Galkowski, 2008 and Blatrix *et al.*, 2018).

One of the principal methods of measuring ant community parameters is pitfall trapping concluded by (Greenslade, 1973; Majer, 1978; Andersen, 1991; De Bruyn, 1993 and Nyamukondiwa and Addison, 2014), so we are used in outdoor trials and bait traps in indoor trials. On the other hand, environmental factors such as temperature, soil, relative humidity, air temperature, and soil moisture were positively correlated with species richness, and seasonal changes in ant numbers but not significantly correlated with pH. Due to the seasonal changes, the number of individuals and species diversity per sample was lower during winter and higher during summer (Kharbani and Hajong, 2013).

Ant societies have developed several behavioural adaptations to beat daily and seasonal variations of climate parameters. (Brian, 1952) studied that at starting of the colony life, queens must select a suitable place to find the nest.

Due to the diversity of true ants, there are many ways to control ant infestation. However, it is yet insufficient and the use of traditional methods, to control the ants, not only resulted in the contamination of the environment but also cause colonies to shatter thus, raising the number of nests reported by (Fonseca *et al.*, 2010). For example, according to (Koren *et al.*, 2003) study, N, N-diethyl-m-toluamide (DEET) as a chemical control is the most effective and most widely used insect repellent obtainable in the market, moreover, (Cox, 2005) study has proven that some people exposed to DEET illustrated symptoms such as headache, drowsiness, vomiting, rashes, and seizures which mark of DEET poisoning. (Batish *et al.*, 2008) agreed with a previous study, that DEET has harmful effects apart from its benefits. Due to the negative results of DEET, (Webb, 2015) said that should replace DEET with plant extracts-based repellents that are considered safer or natural alternatives.

Our aims were, firstly, to study the impact of attractive and chemical repellent materials on the abundance of *M. carbonarium* populations such as bio and chemo-controls, outdoor and indoor urban zone, using pitfall traps and bait traps to detect patterns of competition for food. Second, to study the impact of some physical parameters on ants of *M. carbonarium* population fluctuations.

MATERIALS AND METHODS

The Studied Area:

This work was carried out in 6 sites illustrated in Table (1).

Table 1: The selected sites of attractant trials.

Sites	Abbrev.	Location
Outdoor site 1	A	at the farm of the Faculty of Science building (A), South Valley University, for attractive trials.
Outdoor site 2	B	
Indoor site 1	C	on the fourth floor at the Faculty of Science laboratory building (A).
Indoor site 2	D	on the fifth floor of the Faculty of Science laboratory building (B).
Indoor site 3	E	in El-Gabalawy village, Qena governorate.
Outdoor site	F	at the farm of the Faculty of Science building (A), South Valley University, for repellent trials.

The Attractants:

The scientific and common names for the 10 selected attractants are included in Table (2).

Table 2: The selected attractive materials.

Scientific name	Common name
Sucrose	Sugar
Oryza sativa	Rice
Arachis hypogaea	Peanuts
Vigna unguiculata	Kidney beans
Phoenix dactylifera	Dry dates
Phoenix dactylifera	Ajwa (date paste)
Triticum aestivum	Wheat
Cocos nucifera	Coconut
Vitis vinifera	Currant
Sugarcane molasses	Honey

The Repellents:

The trade and popular names for the 3 selected chemical repellents are illustrated in Table (3).

Table 3: The selected chemical repellent materials.

Trade name	Popular name
Permethrin	Butex
Calcium carbonate	Chalk
Acetic acid	Vinegar

Trap Used for The Experiment:

A new modified pitfall trap was used by applying wooden cubes with a diameter (3.8 * 1 cm) on the water surface containing the attractive tested compounds for the outdoor attractive trials. Moreover, wooden cubes on the water surface containing the chemical repellent tested materials for the outdoor repellent trials, (Fig. 1). Further, indoor trials were carried out using new modified bait traps by applying cork pieces on the cups with a diameter (6 * 6.5 cm) on the water surface containing the attractive tested compounds and cups contain 8 holes drilled in the upper half to facilitate the ants access inside, (Fig. 1).

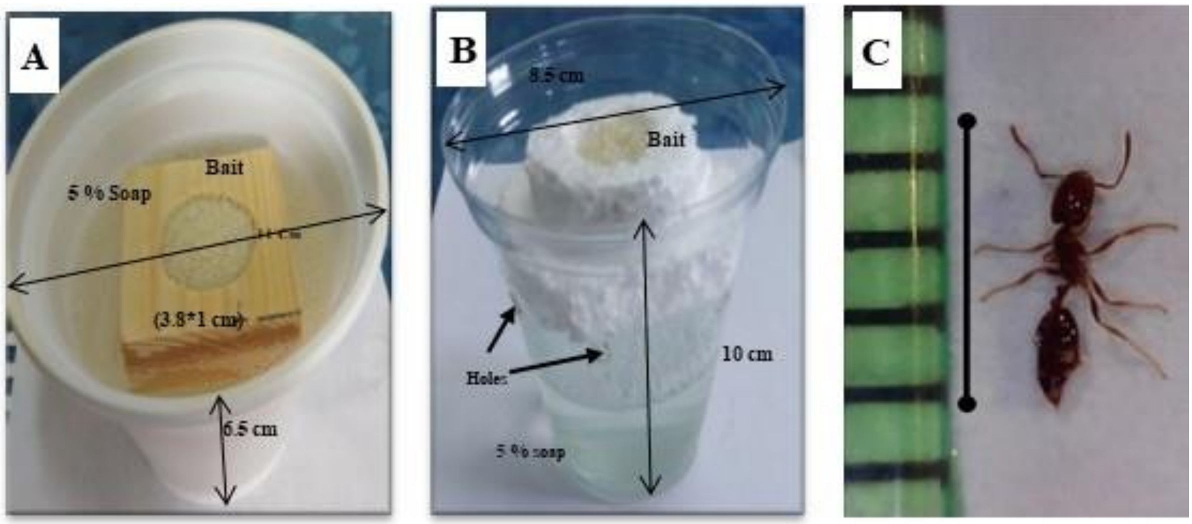

Fig 1: Traps and ant species.
A, outdoor pitfall trap, **B**, indoor bait trap, **C**: Black Little ants, *Monomorium carbonarium*.

Sampling Method:

Thirty pitfall traps were installed at each site using the same attractants and repellents. Traps were situated using Randomized Complete Block Design (RCBD). Each pitfall trap placement was approximately 2 meters apart. Traps were observed weekly to allow the collection of species active at different times of the week. Individuals captured in traps were taken out and washed with clean water to remove soapy residue. (Laub *et al.,* 2009). Then sorted and preserved in 70% ethanol in labelled tubes. *M. carbonarium* were identified in the laboratory at the Faculty of Science building (A), South Valley University based on their external morphology, observed under a dissection microscope (at x40 magnification) (OPTIKA, SZM-1, SN 334654), and according to taxonomic keys (Mohammed, 1979; Bolton, 1994; Collingwood & Agosti, 1996), (Fig. 1).

Statistical Analysis:

The annual population fluctuations for true ants, *M. carbonarium* are illustrated with Graph Pad-prism 9.1.0.221 using logarithm plus 1 to avoid the zero numbers of individuals in the results. Then the difference in the average number of different species of ants visiting each attractive and chemical material was compared by two factorial analyses of variance using a 5% probability level, followed by Tukey's multiple comparisons difference test (GraphPad_Prism_9.1.0.221), (Nyamukondiwa and Addison, 2014).

Furthermore, the effect of the selected meteorological parameters (maximum temperature, minimum temperature, relative humidity, and wind velocity for indoor and outdoor on the abundance of *M. carbonarium*, estimated based on the Pearson's correlation coefficient (correlation "r") using SPSS 25, and then with the Corresponding Canonical Analysis (CCA) test using Canoco for windows 4.5 (Ter Braak, 1987 and Orabi *et al.*, 2011), (Fig. 2). In addition to, figures and heat maps conducted by GraphPad_Prism_9.1.0.221.

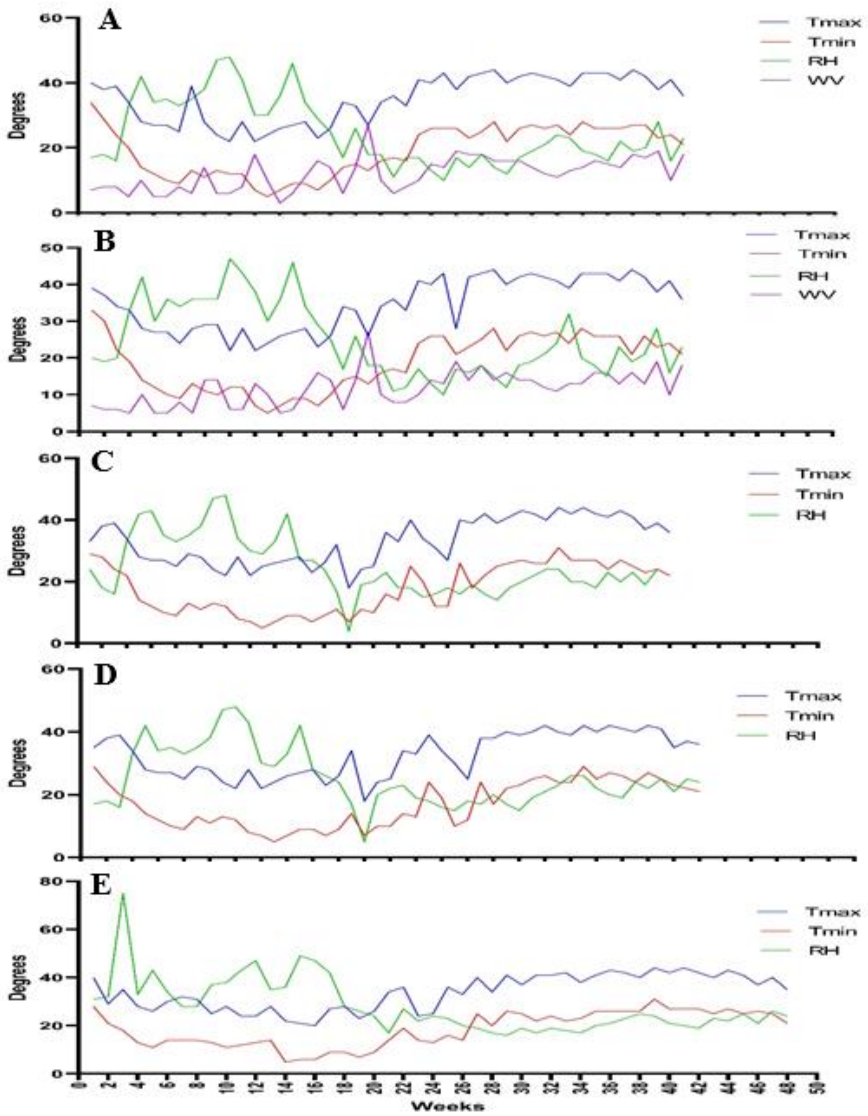

Fig 2: Fluctuation of the different physical factor degrees during the study period (48 weeks) for *Monomorium carbonarium* in all studied sites.
Outdoor sites: (**A** & **B**). Indoor sites: (**C**, **D**, & **E**). **Tmax** (ºC), maximum temperature. **Tmin** (ºC), minimum temperature. **RH** %, relative humidity. **WV** (Km/h), wind velocity.

RESULTS AND DISCUSSION

Annual Population Fluctuations of Attractive Material Trials at Outdoor Sites (A & B):

Results in (Fig. 3) illustrated the annual activity of the black little ants, and the number of individuals for *M. carbonarium* collected by 30 traps every week from October 2020 to September 2021 in outdoor sites in South Valley University, Qena governorate, Egypt. The total number of individuals for *M. carbonarium* recorded over the attractant trials was (14090 individuals). The proportion of this ant species taking place in site B (10550 individuals) was higher than those in site A (3540 individuals). This species belonged to Myrmicinae, presented in a whole year concluded by (Bharti et al., 2009), this study supported the results. Moreover, in site A, the highest number of individuals collected in honey (1242 individuals) acting 35.08 % with a mean number of 141.33 ± 134.39, inversely, the lowest was in kidney beans (28 individuals) representing

0.79 % with a mean number of 5.00 ± 3.61. (Lee, 2002) concluded from their studies conducted on a field population, *Monomorium* sp. demonstrated a seasonal preference for honey and peanut butter baits, thus, this study supported the current findings.

Further, the number of individuals for *M. carbonarium* was subjected to factorial analysis of variance which revealed a highly significant impact on the true ant's attraction with time, replicate, and interaction ($P<0.0001$) but had no significant impact with treatment, (Table 4 and Fig. 4).

Additionally, at site B, the highest number of individuals collected in coconut (3088 individuals) acted 29.27 % with a mean number of 252.00 ± 157.96, inversely, the lowest was in kidney beans (247 individuals) representing 2.34 % with a mean number of 37.00 ± 37.00. (Wilson, 1971) the study concluded, that ant colonies are perennial, and most species have constant nest sites. Though some species may shift their nests often reported by (Smallwood and Culver, 1979) while most species are sedentary. Thus, these studies explained the increase and reduction in the number of individuals of *M. carbonarium* in various nests. Further, (Way and Bolton, 1997) and (Wetterer, 2010) studies found *Monomorium floricola* nesting in coconut trees in most countries, therefore M. carbonarium was highly attracted to coconut than other attractants, though these studies support the findings. The number of individuals for *M. carbonarium* was subjected to factorial analysis of variance which revealed no significant impact on the true ant's attraction with replicate but had a highly significant impact with interaction, time, and treatment ($P<0.0001$). Thus, the number of individuals of *M. carbonarium* had significant differences between (kidney beans, coconut), (ajwa, coconut), and (wheat, coconut) at 0.05 level, (Table 4 and Fig. 4). Besides, (Basu, 1997) study illustrated potent seasonal fluctuations within the ant community and concluded that there were significant differences in total ant abundances from the dry (winter) to the wet (summer) season, of *Monomorium* sp. became dominant and more even in the wet season, the study was supporting the results strongly.

Annual Population Fluctuations of Attractive Material Trials at Indoor Sites (C, D, & E):

Results in (Fig. 3) illustrated the annual activity of the true ants *M. carbonarium*, collected by 30 traps every week on all indoor sites from October 2020 to September 2021 at South Valley University and El-Gabalawy village, Qena governorate, Egypt. The most ants were found in site E, with 20863 individuals accounting for 45.069 % of the total. Additionally, the highest numbers of individuals were recorded at site C in sugar (3129 individuals), representing 33.19 % with a mean number of 274.00 ± 86.40, inversely, the lowest number was reported in kidney beans and wheat in indoor sites, the lowest numbers recorded in kidney beans (174 individuals), representing 1.85 % with a mean number of 10.00 ± 3.21.

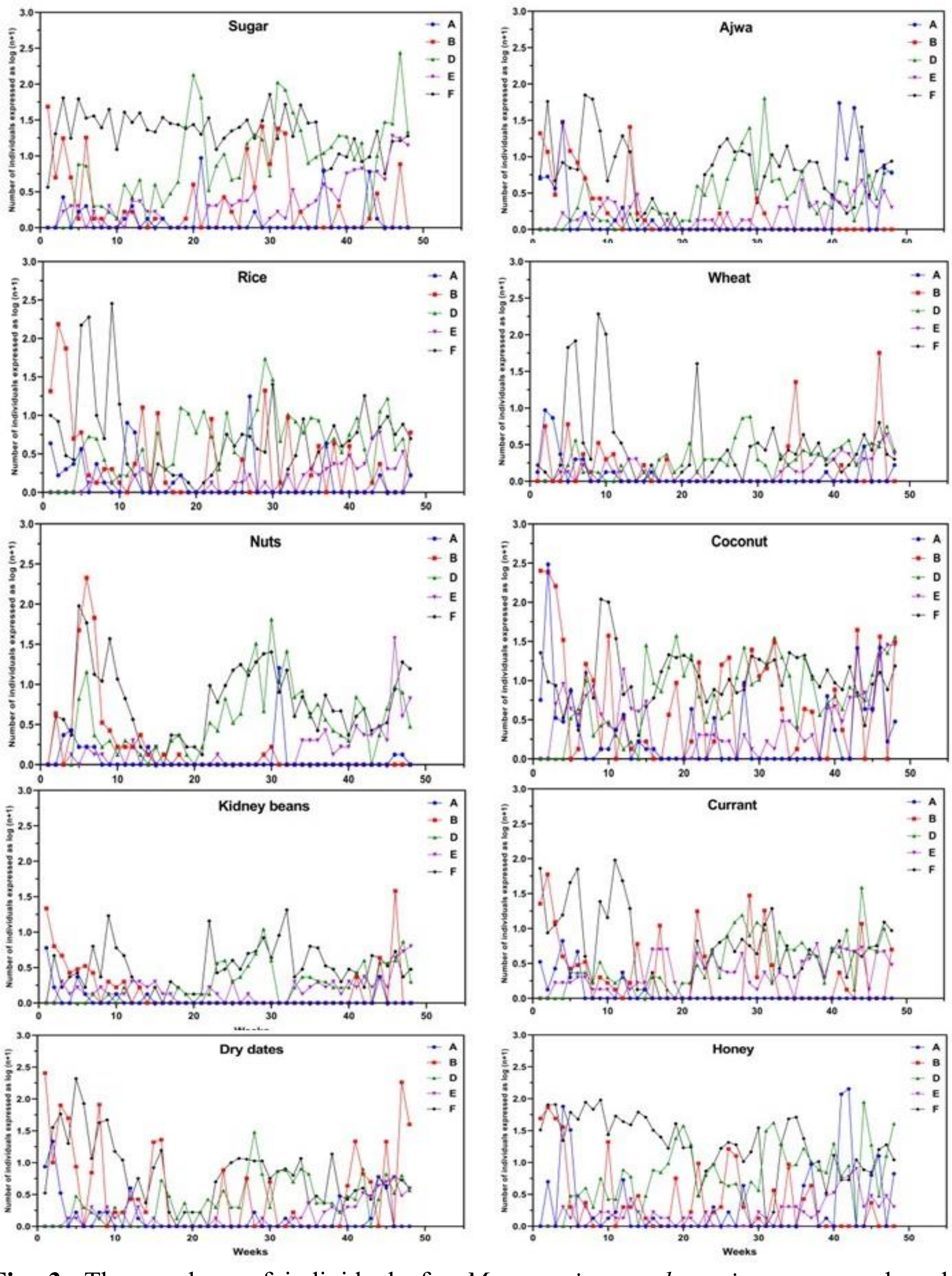

Fig. 3: The numbers of individuals for *Monomorium carbonarium* expressed as log (n+1), collected from sugar, rice, peanuts, kidney beans, dry dates, ajwa, wheat, coconut, currant, and honey from October 2020 till September 2021. Outdoor sites: (A & B). Indoor sites: (C, D, & E).

The number of individuals *M. carbonarium* subjected to factorial analysis of variance revealed not a significant impact on the true ants' attraction with treatment but had a highly significant impact with interaction, time, and replicate ($P<0.0001$). The number of individuals *M. carbonarium* had significant differences between (sugar, rice), (sugar, peanuts), (sugar, kidney beans), (sugar, dry dates), (sugar, ajwa), (sugar, wheat), (sugar, currant), (rice, kidney beans), (rice, wheat), (peanuts, kidney beans), (peanuts, wheat), (kidney beans, coconut), (kidney beans, currant), (kidney beans, honey), (dry dates, coconut), (dry dates, honey), (ajwa, coconut), (wheat, coconut), (wheat, currant), (wheat, honey), (coconut, currant), and (coconut, honey) at 0.05 level, (Table 4 and Fig. 4).

Furthermore, at site D, the highest number was recorded in coconut (528 individuals), representing 27.63 % with a mean number of 27.33 ± 7.88, inversely, the lowest number was reported in wheat (73 individuals) which represented 3.82 % with a mean number of 3.33 ± 0.33. The results agreed with the (Way and Bolton, 1997) and (Wetterer, 2010) studies. The number of individuals for *M. carbonarium* was subjected to factorial analysis of variance which revealed a highly significant impact with interaction, time, replicate, and treatment (P<0.0001) on the true ants' attraction. *M. carbonarium* had a significant difference between (sugar, rice), (sugar, kidney beans), (sugar, dry dates), (sugar, ajwa), (sugar, wheat), (rice, coconut), (rice, currant), (kidney beans, currant), (dry dates, coconut), (dry dates, currant), (ajwa, coconut), (ajwa, currant), (wheat, coconut), (wheat, currant), (coconut, honey), and (currant, honey) at 0.05 level, (Table 4 and Fig. 4).

Finally, at site E, the highest number was recorded in honey (4057 individuals), representing 19.45 % with a mean number of 94.33 ± 46.39 but the lowest number was reported in kidney beans (461 individuals), representing 2.21 % with a mean number of 19.67 ± 11.61. The results agreed with the (Lee, 2002) study. The number of individuals for *M. carbonarium* was subjected to factorial analysis of variance which revealed a highly significant impact with replicate, treatment time, and interaction (P<0.0001) on the true ant's attraction. *M. carbonarium* had a significant difference between (sugar, peanuts), (sugar, kidney beans), (sugar, ajwa), (sugar, wheat), (sugar, currant), (peanuts, honey), (kidney beans, ajwa), (kidney beans, coconut), (ajwa, honey), (wheat, honey), (coconut, honey), and (currant, honey) at 0.05 level, (Table 4 and Fig. 4). (Espadaler and Castillo, 2014) studied *M. carbonarium* is determined indoors in Spain and concluded the ants appear in spring and stay active during summer and reveal an increasing number in hotter weather. In autumn and winter, they do not appear activity either outdoors or indoors. These trails are formed whenever food is detected, no control measures have been taken yet. These studies partly coincide with the results of the current study.

The Population Fluctuations of Repellent Trials at The Outdoor Site (F):

In the case of repellent materials, the total number of individuals in site (F) was (111 individuals), and the highest number of individuals collected in vinegar (78 individuals), representing 70.27 % with a mean number of 24.00 ± 24.00 in the presence of the highest attractive materials was coconut. *M. carbonarium* hasn't visited the traps of vinegar in the presence of rice, dry dates, ajwa, wheat, currant, and honey, followed by butex, the total number of individuals (27 individuals) representing 24.32 % with a mean number of 6.67± 6.67, inversely, the lowest were in chalk (6 individuals) acting at 5.41 %, (Table 5 and Fig. 5). *M. carbonarium* was subjected to factorial analysis of variance which revealed no significant impact of the true ant's attraction on time, replicate, interaction, and treatment, (Table 4 and Fig. 4).

Table 4: Analysis of variance comparison table for mean numbers of individuals for ***Monomorium carbonarium*** attracted to 10 materials in outdoor (A & B), indoor sites (C, D, & E), and chemical repellent site (F).

Sites	Source of variation	DF	SS	MS	F-value	P-value
A	Interaction	423	352903	834.3	2.057	<0.0001
	Time	47	49919	1062	2.618	0.0002
	Replicate	9	14611	1623	6.335	0.0003
	Treatment	20	5126	256.3	0.6317	0.8911
B	Interaction	423	755979	1787	1.693	<0.0001
	Time	47	265293	5645	5.348	0.0024
	Replicate	9	57790	6421	2.072	0.0839
	Treatment	20	61985	3099	2.937	<0.0001
C	Interaction	423	322594	762.6	4.648	<0.0001
	Time	47	73346	1561	9.512	<0.0001
	Replicate	9	49270	5474	41.11	<0.0001
	Treatment	20	2663	133.2	0.8117	0.7011
D	Interaction	423	8169	19.31	1.820	<0.0001
	Time	47	4425	94.16	8.875	0.0003
	Replicate	9	1277	141.9	4.653	0.0020
	Treatment	20	610.1	30.50	2.875	<0.0001
E	Interaction	423	621641	1470	1.935	<0.0001
	Time	47	374454	7967	10.49	<0.0001
	Replicate	9	70926	7881	4.515	0.0024
	Treatment	20	34912	1746	2.298	0.0010
F	Interaction	18	1161	64.51	1.031	0.4500
	Time	9	494.8	54.97	0.8721	0.5643
	Replicate	2	91.40	45.70	0.7300	0.4171
	Treatment	20	1261	63.03	1.007	0.4757

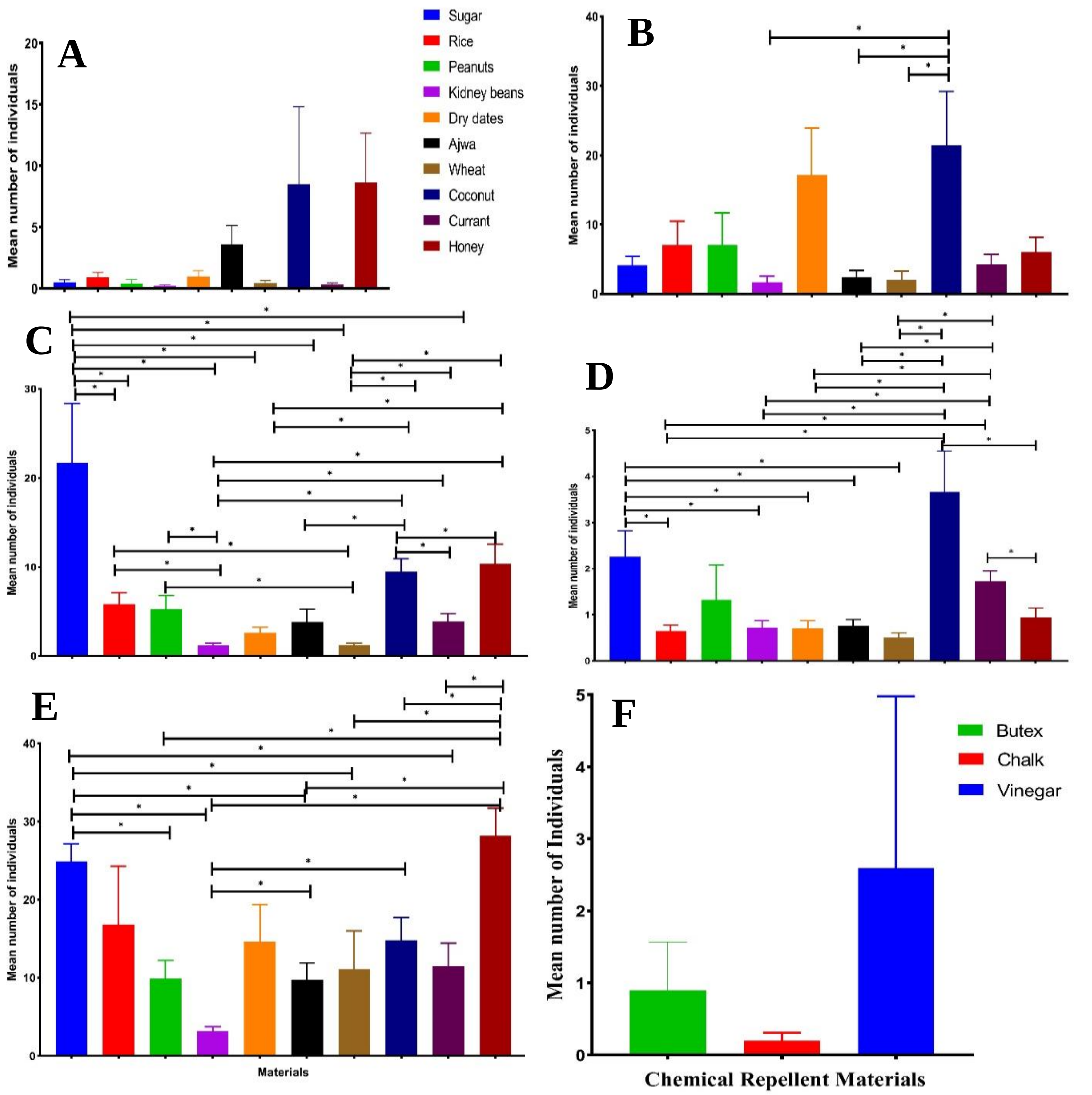

Fig. 4: The Mean number of individuals & SE for *Monomorium carbonarium* collected from outdoor (A & B), and indoor (C, D, E & F) sites. (*) The mean difference is significant at the 0.05 level.

Table 5: The numbers of individuals and percentages of ***Monomorium carbonarium*** collected by pitfall traps at the outdoor site (F).

Attractive materials	Butex		Chalk		Vinegar	
	No.	%	No.	%	No.	%
sugar	0	0.00	1	0.90	1	0.90
rice	6	5.41	0	0.00	0	0.00
peanuts	0	0.00	2	1.80	4	3.60
kidney beans	1	0.90	3	2.70	1	0.90
dry dates	0	0.00	0	0.00	0	0.00
ajwa	0	0.00	0	0.00	0	0.00
wheat	0	0.00	0	0.00	0	0.00
coconut	0	0.00	0	0.00	72	64.86
currant	20	18.02	0	0.00	0	0.00
honey	0	0.00	0	0.00	0	0.00

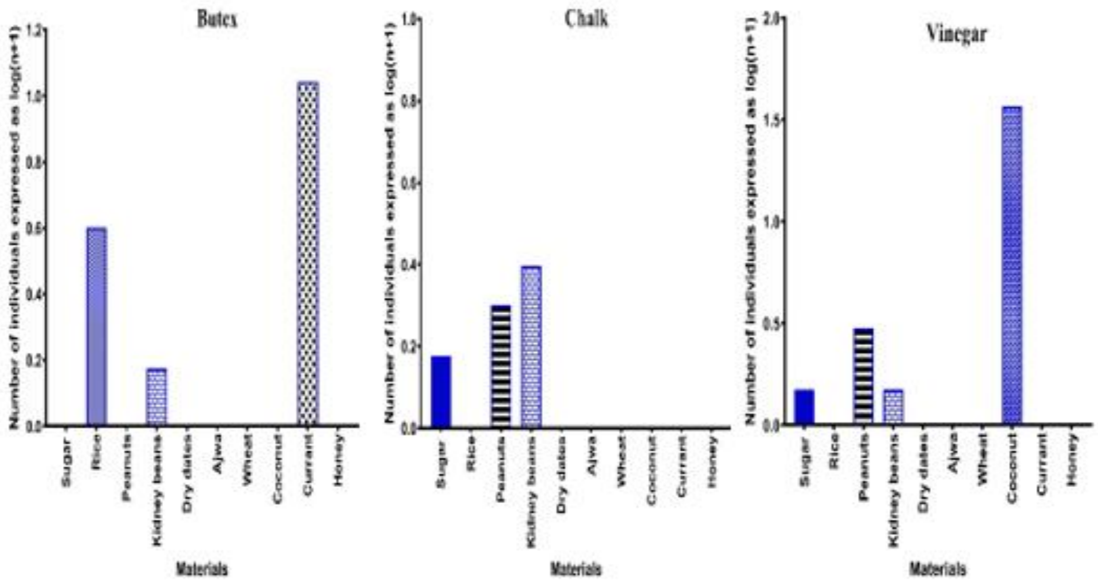

Fig 5: The numbers of individuals for ***Monomorium carbonarium*** expressed as log (n+1) collected from butex, chalk, and vinegar as a repellent at the outdoor site (F).

(Knight and Rust, 1990) concluded that residual sediment of cypermethrin and cyfluthrin were highly repellent but permethrin and chlorpyrifos were moderately repellent. This study supported and agreed on the funding in *M. carbonarium* with butex. The black little ants demonstrated the highest numbers passed near vinegar to the attractive managing material rather than others. This explanation disagrees with that of (Naung, 2015) who studied fire ants and used three different concentrations of vinegar (50%, 60%, and 70%) to repel them and the number of repelled fire ants in various hours, so he observed different concentrations of vinegar give various repellent effects in every hour and the optimum dose of acetic acid to be used as a repellent on fire ants is 70% and the most effective dose in the first three hours, that vinegar does have a potential repellent effect on fire ants. Thus, the study slightly disagreed with vinegar and coconut which revealed highly attractive properties.

In Khan *et al.,* 2018 study, the vinegar used had a strong odor, when tested, it influenced the ants by slowing them down. Although it did not kill them, the vinegar appeared to just be a nuisance to the ants, causing them to reduce in speed and activity or stay still. The vinegar did not completely stop the ants from crossing the border that was made, but it did to some extent decrease the number of ants that crossed. Overall, the vinegar proved to be practically ineffective in killing the ants but was generally successful in confusing them. This study agreed with the finding in the presence of coconut, vinegar prevents the ants from crossing the border of the trials. The vinegar does have a special scent that will cause the ants to be disoriented, which is a state the insects were to remain in until the surrounding vinegar breaks down and the ants were then able to continue the way. Vinegar is a suitable temporary solution to prevent ants.

Mfarrej and Rara, 2019 study concluded that vinegar was effective in repelling pests with very low degradation, while water and vinegar were mixed the resulted combination revealed effectiveness as a repellent. Therefore, the results of (Mfarrej and Rara, 2019) quietly disagreed with the vinegar and coconut of the current study.

Effect of Some Meteorological Parameters on Annual Fluctuations of Black Little Ants, *M. carbonarium:*

Effect of Maximum Temperature (ºC):

Data in Table (6) and (Fig. 6) demonstrate the Pearson's correlation coefficient values between the annual fluctuation of true ants, *M. carbonarium*, and meteorological parameters. Results indicated that an insignificant positive correlation effect at a 0.05 level of probability was recorded at site A in honey, site B in coconut, site C in sugar, and site D in coconut, respectively between maximum temperature and *M. carbonarium*, where (r = 0.196, r= 0.119, r= 0.184, and r= 0.095). However, a significant negative correlation effect at a 0.05 level of probability was recorded at site E in honey, between the maximum temperature and *M. carbonarium*, (r =-0.483). (Botnevik *et al.*, 2016) study suggested that temperature had an important effect on time giver in the circadian rhythm of ant behaviour, and as the same stimulus for the connection of ants to attractants, though concluded that their study revealed a significant effect of temperature on tetany in ants, while neither light nor relative humidity influenced this behaviour, thus, the study agreed the current findings.

Effect of Minimum Temperature (ºC):

Results in a Table (6) and (Fig. 6) suggest that the minimum temperature had an insignificant positive correlation effect at 0.05 level of probability recorded at site A in honey, site C in sugar, and site D in coconut, respectively between minimum temperature and *M. carbonarium*, where (r = 0.186, r= 0.128, and r= 0.165). However, a significant negative correlation effect at a 0.05 level of probability was recorded at site E in honey, between the minimum temperature and *M. carbonarium*, (r =-0.420). Furthermore, a significant positive correlation effect at a 0.05 level of probability was recorded at site B in coconut, between the minimum temperature and *M. carbonarium*, (r = 0.380). (Kannowski, 1959) and (Talbot, 1945 & 1959) studies concluded that there were differences in the connection between air temperature, time, and relative humidity for North American ant species, though these studies support the present findings. Brian et al., 1966 studied those nuptial flights will not occur if, at flight hours, air temperatures are significantly higher or lower than soil temperatures. Furthermore, (Boomsma and Leusink, 1981) said dispersal during nuptial flights is an important process in preserving the ant species so they can avoid unfavourable weather conditions, further preferences for specific flight weather conditions can be observed in many ant species.

Effect of Relative Humidity (%):

Pearson's correlation coefficient values were obtained from a Table (6) and (Fig. 6), which illustrated that the relative humidity had an insignificant negative correlation effect at a 0.05 level of probability recorded at site A in honey, site B in coconut, and site C in sugar, respectively between relative humidity and *M. carbonarium*, where (r = -0.056, r= -0.147, and r= -0.173). However, an insignificant positive correlation effect at a 0.05 level of probability was recorded at site D in coconut, between the relative humidity and *M. carbonarium*, (r = 0.137). Further, a significant positive correlation effect at a 0.05 level of probability was recorded at site E in honey, between the relative humidity and *M. carbonarium*, (r =-0.584). (McGinnies *et al.*, 1969) and (Edney et al., 1978) studies concluded that fluctuations of evaporation and soil temperatures rise relative humidity and moisture gradients in animal burrows such as temperature, moisture, and relative humidity levels change more closely near the soil surface than at increasing depths.

Moreover, (Hackman and Rockstein, 1964) concluded that the workers of ants responded positively to increased relative humidity though selecting areas of highest humidity, though these studies agreed with the current results. Furthermore, (Potts et al., 1984) study said the response of ants in general to humidity in lack of superimposed thermal gradients has little pay attention.

Table 6: Pearson's correlation coefficient of weather factors with *Monomorium carbonarium* at outdoor (A & B) and indoor sites (C, D, & E).

Materials \ Weather factors	Sites	T.max (°C)	T.min (°C)	RH %	WV (Km/h)
Sugar	A	0.065	0.030	-0.078	-0.162
Rice		-0.034	0.058	0.144	-0.231
Peanuts		0.117	0.060	-0.122	0.129
Kidney beans		0.077	0.273	-0.044	-0.122
Dry dates		0.129	**0.320***	-0.107	-0.136
Ajwa		0.243	0.254	-0.086	0.057
Wheat		0.087	0.207	-0.103	-0.200
Coconut		0.078	0.214	-0.092	-0.099
Currant		-0.123	0.017	0.202	**-0.384***
Honey		0.196	0.186	-0.056	0.059
Sugar	B	0.226	**0.358***	-0.268	-0.119
Rice		0.061	0.259	-0.114	-0.254
Peanuts		-0.223	-0.195	0.184	-0.276
Kidney beans		0.103	0.222	0.025	0.070
Dry dates		0.085	0.243	-0.088	-0.236
Ajwa		-0.137	0.035	0.281	**-0.421***
Wheat		0.104	0.123	0.038	0.216
Coconut		0.119	**0.380***	-0.147	-0.243
Currant		0.140	**0.290***	-0.160	-0.154
Honey		0.051	0.282	-0.101	**-0.332***
Sugar	C	0.184	0.128	-0.173	--
Rice		0.009	-0.101	**-0.302***	--
Peanuts		0.029	0.015	-0.230	--
Kidney beans		0.172	0.133	**-0.360***	--
Dry dates		0.218	0.196	**-0.325***	--
Ajwa		0.180	0.167	-0.280	--
Wheat		0.276	0.209	**-0.299***	--
Coconut		0.114	-0.020	-0.281	--
Currant		**0.360***	0.323*	**-0.322***	--
Honey		**0.286***	0.190	-0.204	--
Sugar	D	**0.337***	**0.391***	-0.129	--
Rice		**0.481***	**0.484***	-0.082	--
Peanuts		0.117	0.192	-0.074	--
Kidney beans		0.218	0.252	0.010	--
Dry dates		**0.392***	**0.432***	-0.027	--
Ajwa		**0.346***	**0.349***	0.069	--
Wheat		**0.329***	**0.382***	0.043	--
Coconut		0.095	0.165	0.137	--
Currant		0.234	0.232	-0.151	--
Honey		**0.400***	**0.401***	-0.005	--
Sugar	E	-0.234	-0.239	**0.360***	--
Rice		-0.214	-0.163	0.193	--
Peanuts		-0.120	-0.104	0.089	--
Kidney beans		0.193	0.195	-0.192	--
Dry dates		-0.234	-0.216	**0.382***	--
Ajwa		-0.079	-0.036	0.006	--
Wheat		-0.244	-0.214	0.221	--
Coconut		-0.154	-0.131	0.099	--
Currant		-0.209	-0.102	**0.352***	--
Honey		**-0.483***	**-0.420***	**0.584***	--

Tmax= maximum temperature, Tmin= minimum temperature, RH %= relative humidity, WV = wind velocity, -- = no recorded wind velocity values for indoor sites.
(*) Correlation is significant at the 0.05 level.

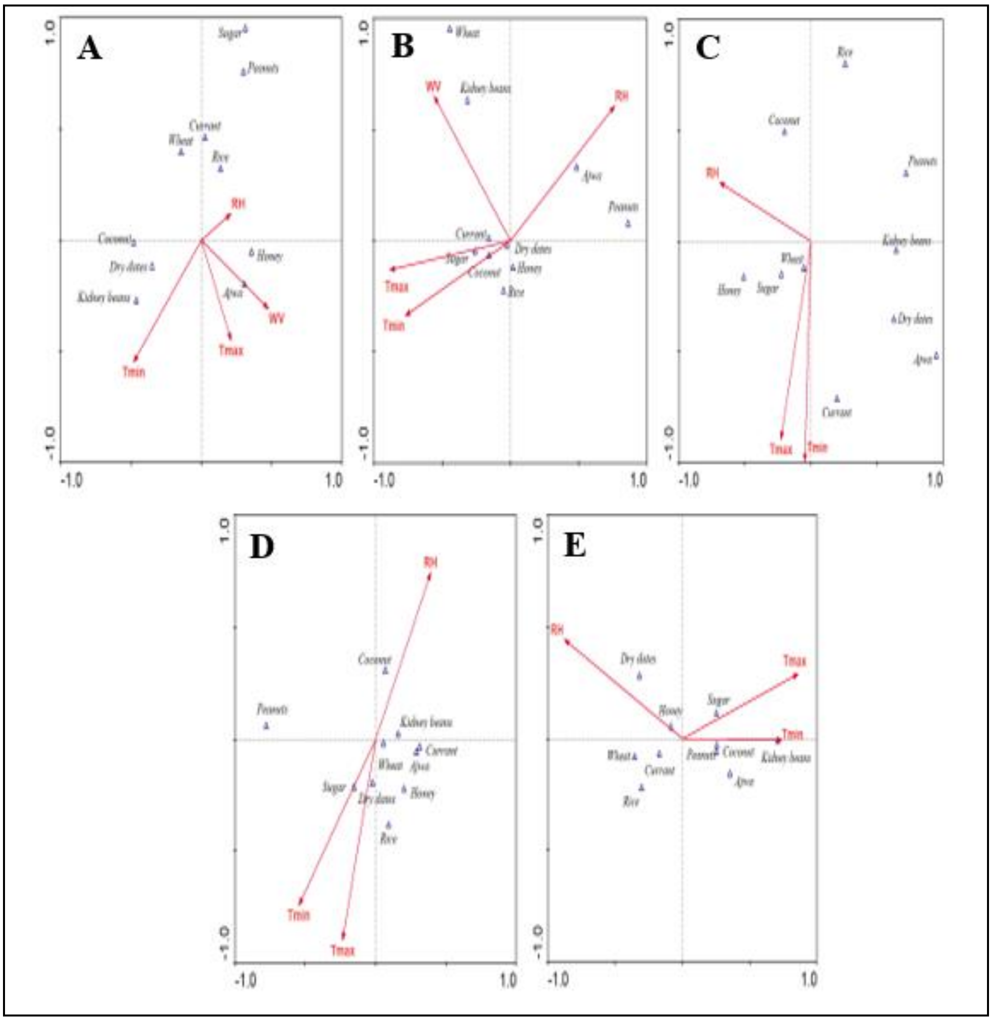

Fig (6): The effect of mereological factors on annual population fluctuations of true ants, *Monomorium carbonarium* for outdoor (A & B) and indoor sites (C, D, & E) by Canonical Corresponding Analysis (CCA), where Tmax = maximum temperature, Tmin = minimum temperature, RH%= relative humidity %, and WV= wind velocity.

Effect of Wind Velocity (Km/h):

Pearson's correlation coefficient values were obtained from a Table (6) and (Fig. 6), which demonstrated that the wind velocity had an insignificant positive correlation effect at 0.05 level of probability recorded at site A in honey between wind velocity and *M. carbonarium*, where (r = 0.059). However, an insignificant negative correlation effect at a 0.05 level of probability was recorded at site B in coconut, between the wind velocity and *M. carbonarium*, (r = -0.243). (Wehner and Duelli, 1971) study said that desert ants would be able to use the moon and orientation mechanism which concluded that had not influenced by the angle height of the moon or wind velocity, thus this study agreed with the present results. (Kleineidam *et al*., 2001) study that there are two main leading forces for passive nest ventilation: temperature and wind velocity. Moreover, wind-induced nest ventilation is highly effective during summer. However, in autumn, colonies of ants near the nest entrances so that wind is perhaps strongly reduced.

According to the current finding, the highest number of black little ants was in site (E) because ants were affected by various weather factors in this site which revealed decreasing in maximum and minimum temperatures and increasing in wind velocity.

CONCLUSION

Finally, it was concluded that total ant abundance, species richness, and their behaviours toward attractive materials varied significantly in honey followed by coconut from autumn to summer, and the abundance of ants was higher during warmer seasons. Further, chalk demonstrated high repellency to *M. carbonarium* in the presence of attractants. temperature, RH%= relative humidity %, and WV= wind velocity.

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ARABIC SUMMARY

دراسات على مواد جاذبة وطاردة كيميائية مختارة للنمل تحت تأثير العوامل المناخية على التقلبات العشائرية للنمل الصغير الأسود الشائع، *Monomorium carbonarium* (F. Smith 1858) (Hymenoptera: Formicidae)

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يهدف هذا البحث إلي دراسة تأثير المواد الجاذبة للنمل و بعض المواد الكيميائية الطاردة للنمل تحت تأثير بعض العوامل الفيزيائية على التوزيع الموسمي لنوع *Monomorium carbonarium*. و قد اُستخدمت مصائد الأشراك الأرضية مع إجراء بعض التعديلات عليها للتجارب التي أجريت في الحقل ومصائد الطعوم للتجارب التي أجريت داخل المباني. هذا و قد اُستخدمت عشرة أنواع من المواد المعروفة بجذبها للنمل (السكر، الأرز، الفول السوداني، اللوبيا، التمر المجفف، العجوة، القمح، جوز الهند، الزبيب والعسل) بالإضافة إلى استخدام ثلاث مواد كيميائية كمواد طاردة (بيوتكس والجير الحي والخل). وقد أظهرت النتائج أن العسل كان أكثر المواد التي جذبت هذا النوع (4057 فرد) بنسبة 19.45%. وعلي العكس كانت اللوبيا أقل ماده قد أُنجذب إليها النمل (461 فرد) بنسبة 2.21%. وأظهرت النتائج أن أعلي أعداد انجذبت إلى جوز الهند مع الخل (78 فرد) وأقلهم مع الجير الحي (6 أفراد). وقد أظهرت التحاليل الإحصائية أن درجات الحرارة العظمي والصغرى كان لها تأثير طردي معنوي علي وفرة *M. carbonarium* في كل المواقع فيما عدا الموقع E والتي كان له تأثيرًا عكسيًا معنويًا علي أعداد هذا النوع من النمل. بالإضافة إلي ذلك كان للرطوبة النسبية تأثيرًا إيجابيًا معنويًا علي النمل في المواقع A و D و E وتأثيرًا سلبيًا معنويًا علي المواقع الأخرى. وأظهر أيضًا تحليل التباين تأثرًا كبيرًا للمواد الجاذبة جميعًا في المواقع B و D و E. وتم استنتاج أن هذا النوع ينجذب بكثرة إلي كل من العسل وجوز الهند. علاوة علي ذلك فإنه وفرة هذا النوع تتناسب عكسيًا مع درجات الحرارة والرطوبة النسبية و لمكافحة هذا النوع يُستخدم الجير الحي. لذلك يوصي بتخزين المواد التي تمت دراستها في هذا البحث في مخازن مغلقه وبعيده عن الرطوبة.